Shallow-Water Acoustic Reverberation

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LONG-TERM GOALS

The long-term goals are: to develop a theoretical model for predicting the reverberation in shallow water, to derive both small-angle seabed reflectivity and scattering strength from reverberation data at low frequency, and to understand the physical mechanism of sea bottom scattering.

OBJECTIVES

The scientific objective of this research is to investigate the effects of sea bottom on sound propagation, reverberation and signal coherence. Our objectives are (I) to analyze the range/ depth dependence of reverberation intensity and its spatial coherence for frequencies of 200-3000 Hz. (II) To compare the theoretical predictions on reverberation with at-sea experimental data. (III) To derive seabottom acoustic parameters from reverberation data, such as bottom reflectivity and scattering as a function of frequency and angle.

BACKGROUND

"The seabed is the king of the shallow water acoustics problem." Grazing angles of incidence of primary importance to shallow-water long-range propagation/reverberation are from about 15 degrees to near 0 degree with the smaller angles being more important. The bottom scattering strength at small grazing angles is generally derived from reverberation measurements. Up to now, there are few publications on shallow-water reverberation-derived bottom scattering data at low frequency and low grazing angles. Bottom scattering mechanisms and related parameters are also poorly known. Thus, reverberation models for shallow-water are not as well developed as propagation loss models ``Today, the poor engineer working on an active sonar system is still without easily applied methods or models for predicting the echo--reverberation ratio to be expected in his system." Several theoretical models for seabed scattering have been developed. These models need be evaluated and tested by both at-sea reverberation data and low-frequency bottom scattering data.

APPROACH

A comparison is made between theoretical predictions and at-sea experimental data. The predictions include the average reverberation level (RL) and the reverberation vertical/horizontal coherence, derived from the R-mode theory. The experimental data are obtained from different sites with different sediments, including the U.S.-China joint Yellow Sea' 96 experimental area. The reverberation data and the theoretical results are also used to derive seabed acoustic parameters.

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RESULTS

(1) The range/depth dependence of reverberation intensity has been analyzed for several sites in frequencies of 200-3000 Hz. Fig 1 shows that in the Yellow Sea with a strong thermocline both sound transmission loss (TL) and RL exhibit strong depth dependence. (Curve a: both source and receiver are located below the thermocline; curve b: the source and receiver are located separately above and below the thermocline.) (II) The vertical cross-correlation coefficient of reverberation as a function of time, frequency and hydrophone separation has been analyzed. (III) The bottom reflectivity and scattering strength at low frequencies and low grazing angles have been simultaneously derived from reverberation data (vertical coherence and intensity range dependence). Fig. 2 shows that the bottom scattering strength at small grazing angles is heavily frequency dependent. (the RL itself used for the inversion has rather weak frequency dependence). (IV) Scale model experiments have been conducted to study the diffraction of sound by an underwater convex surface with a very soft boundary. The data analysis is in progress.

IMPACT/APPLICATION

The results will be helpful for developing an easily applied model for predicting the echo--reverberation ratio in shallow water. The experimental data on reverberation intensity and bottom scattering strength will contribute to a database for testing reverberation/seabed scattering models.

RELATED PROJECTS

A joint NICOP program between Georgia Institute of Technology and the Institute of Acoustics in Beijing, supported by both the ONR Asian office and Ocean Acoustics Program, is ongoing at Georgia Tech.

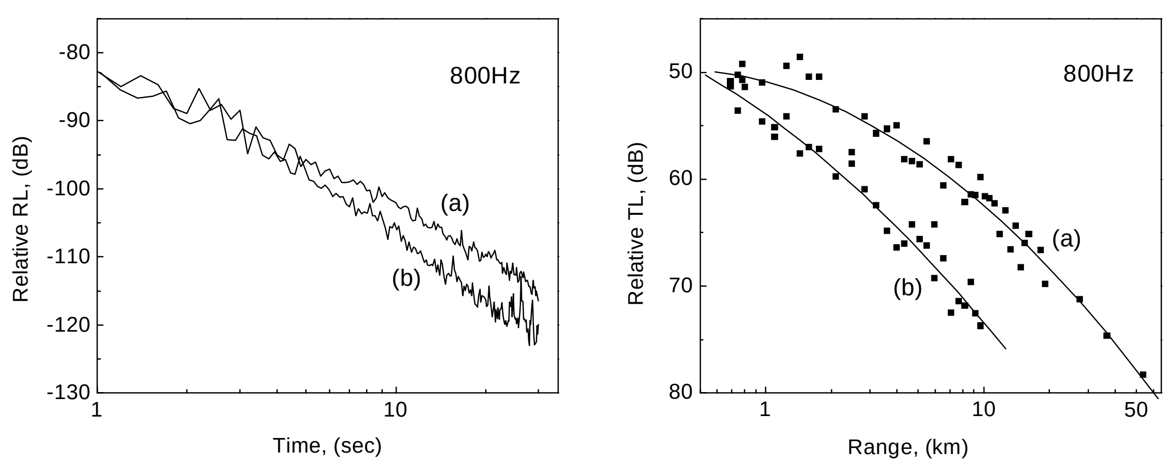

FIG. 1 Range/depth dependence of RL and TL in the Yellow Sea

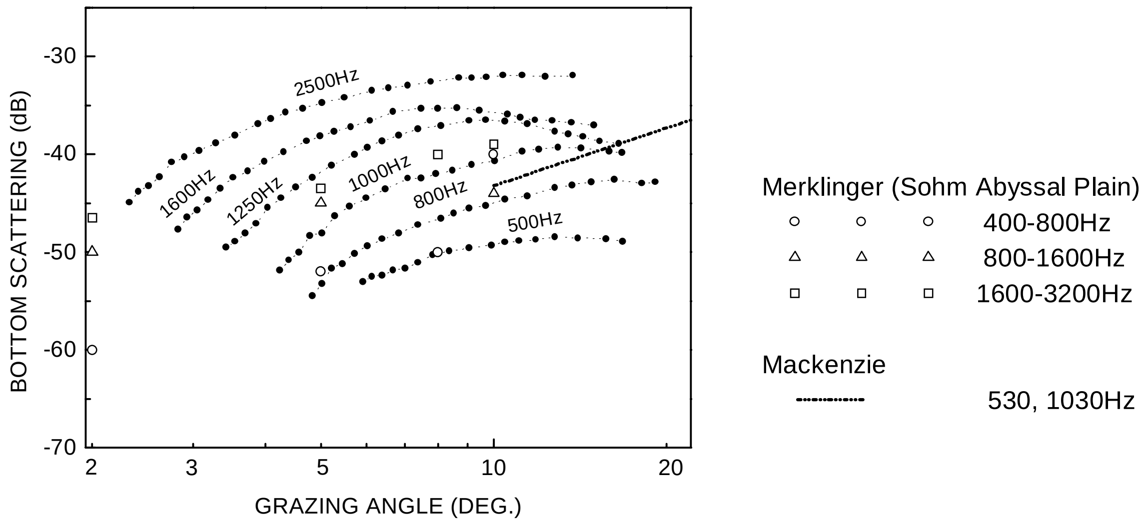

FIG. 2 Reverberation-derived bottom backscattering strength at small grazing angles